CLAIMS

1. A low pressure fluctuation control apparatus comprising:

recirculation loop for recirculating a liquid, said recirculation loop comprising in fluid communication: a dip tube, a pump, a regulator, a flow meter, a junction, a return tube downstream of said junction and a back pressure controller located in said return tube;

material supply line in fluid communication with said recirculation loop via said junction;

flow control system in said material supply line;

wherein said recirculation loop draws said liquid from a supply container via said dip tube and returns at least a portion of said liquid to the supply container via said return tube ,

wherein said pump is a diaphragm or bellows type pump.

2. The apparatus of claim 1 further wherein said flow control system comprises a flow controller.

3. The apparatus of claim 2 further wherein said flow controller comprises a flow meter and a controlled regulator in fluid communication.

4. The apparatus of any of the preceding claims wherein said at least one flow meter is a flow transmitter.

5. The apparatus of any of the preceding claims wherein said flow meters are flow transmitters.

6. The apparatus of any of the preceding claims wherein said flow meter in said flow control system is a flow transmitter.

7. The apparatus of any of the preceding claims wherein said regulator in said recirculation loop is controlled by a direct-operated air regulator.

8. The apparatus of any of the preceding claims wherein said flow control system further comprises an isolation valve.

9. The apparatus of any of the preceding claims wherein said flow meter in said recirculation loop is a flow transmitter that is electrically connected to a controller that receives a signal from said flow transmitter and adjusts a pilot pressure to said pump in response to said signal.

10. The apparatus of any of claims 2 – 9 wherein the flow controller comprises a control valve and flow meter, said flow meter of said flow controller is downstream of the control valve of the flow controller in the flow control system.

11. The apparatus of any of the preceding claims wherein said regulator comprises two diaphragms.

12. The apparatus of any of the preceding claims wherein said regulator is selected from the group consisting of spring-loaded, pneumatic, weight-loaded, linear-actuated, and motor-loaded regulators.

13. The apparatus of any of claims 2-12 wherein said flow control system further comprises a check valve downstream of said flow controller.

14. The apparatus of any of the preceding claims wherein said recirculation loop further comprises tubes connected to said dip tube, said pump, said regulator, said flow meter, and said junction in said recirculation loop to provide said fluid communication therebetween.

15. The apparatus of any of claims 2-14 wherein said flow control system further comprises tubes connecting said flow controller to said junction to provide said fluid communication.

16. The apparatus of claim 6-15 wherein said flow controller in said flow control system receives a signal from said flow transmitter in said flow control system and adjusts said gas pressure to said controlled regulator in response to said signal.

17. The apparatus of any of the preceding claims wherein said back pressure controller comprises a valve and a flow meter.

18. The apparatus of any of the preceding claims wherein said back pressure controller comprises a needle valve and a rotometer.

19. The apparatus of any of the preceding claims wherein said back pressure controller comprises a pressure transducer, a controller and a pneumatic actuated valve.

20. The apparatus of any of the preceding claims wherein said recirculation loop further comprises a filter in said recirculation loop.

21. The apparatus of any of claims 3-20 wherein said controlled regulator comprises two diaphragms.

22. The apparatus of any of claims 3-21 wherein said regulator and said controlled regulator each comprise two diaphragms.

23. The apparatus of any of the preceding claims wherein said flow meter in said recirculation loop is downstream of said regulator in said recirculation loop and provides backpressure to said regulator.

24. The apparatus of any of the preceding claims wherein said pump is a cross-phase pump.

25. The apparatus of any of the preceding claims wherein the regulator in the recirculation loop is sized such that the ratio of a maximum volumetric flow rate of the regulator to a maximum volumetric flow rate of said pump is between 2.5:1 to 5.5:1.

26. The apparatus of any of the preceding claims wherein a gas backpressure in the pump is equal to or greater than a liquid pressure in the recirculation loop when the liquid pressure is measured in the recirculation loop between the pump and the junction.

27. The apparatus of any of the preceding claims wherein a gas backpressure in the pump and a venturi pressure in the pump are equal +/- 10%.

28. The apparatus of any of the preceding claims further comprising:

a second flow controller for a liquid component to be mixed with the liquid to make a liquid blend; the second flow controller being closed-loop control type;

second junction or manifold where the liquid and the liquid component form a blended liquid;

wherein said pump provides means for adjusting its speed and means for adjusting one or more or all of the following: chamber overlap, gas backpressure, venturi pressure and gas and vacuum flow to the diaphragms or bellows;

and wherein the apparatus directs 20% or less of the liquid in the recirculation loop to the liquid material supply line.

29. The apparatus of claim 28, where said gas backpressure is equal to or greater than a liquid pressure in the recirculation loop when the liquid pressure is measured in the recirculation loop between the pump and the first junction with the liquid material line.

30. The apparatus of claim 28 or 29, where the gas backpressure and the venturi pressure in the pump are equal +/- 10%.

31. The apparatus of any of claims 28-30 wherein the backpressure controller in the recirculation loop is manually, electronically or pneumatically adjustable.

32. The apparatus of any of claims 28-31 wherein said flow controller for the liquid is set at 1-20 or 2-8 or 1-3 LPM.

33. A method of operating the apparatuses of any of the preceding claims comprising the steps of:

pumping a liquid out of a liquid supply container into a recirculation loop via a pump in said recirculation loop at a pressure to provide a liquid having a pressure;

flowing the liquid through a regulator downstream of said pump in said recirculation loop to suppress pressure fluctuations in said liquid caused by the pumping step;

recirculating at least a portion of the liquid back to said liquid supply container in a return portion of the recirculation loop after passing said liquid through a back pressure controller located in said return portion of the recirculation loop; and

passing the balance of the liquid from the recirculation loop through a flow controller in a material supply line in fluid communication with said recirculation loop, wherein the flow controller provides a controlled volume of liquid downstream of the flow controller.

34. The method of claim 33 wherein during said

recirculating step, directing 20% or less of said liquid to said material supply line.